Environmental Science and Policy 79 (2018) 45–53

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Review

Participatory scenario planning and climate change impacts, adaptation and vulnerability research in the Arctic

Melanie Flynn[a,*], James D. Ford[a], Tristan Pearce[b], Sherilee L. Harper[c], IHACC Research Team[d]

[a] The Priestley International Centre for Climate, University of Leeds, UK
[b] University of the Sunshine Coast, Queensland, Australia
[c] University of Guelph, Guelph ON, Canada
[d] Indigenous Health Adaptation to Climate Change Research Team, Lea Berrang-Ford, Cesar Carcamo, Alejandro Llanos, Shuaib Lwasa, Didacus Bambaiha Namanya

ARTICLE INFO

Keywords:
Participatory scenario planning
Arctic
Climate change
Impacts
Adaptation
Vulnerability

ABSTRACT

Participatory scenario planning (PSP) approaches are increasingly being used in research on climate change impacts, adaptation, and vulnerability (IAV). We identify and evaluate how PSP has been used in IAV studies in the Arctic, reviewing work published in the peer-reviewed and grey literature (n = 43). Studies utilizing PSP commonly follow the stages recognized as 'best practice' in the general literature in scenario planning, engaging with multiple ways of knowing including western science and traditional knowledge, and are employed in a diversity of sectors. Community participation, however, varies between studies, and climate projections are only utilized in just over half of the studies reviewed, raising concern that important future drivers of change are not fully captured. The time required to conduct PSP, involving extensive community engagement, was consistently reported as a challenge, and for application in Indigenous communities requires careful consideration of local culture, values, and belief systems on what it means to prepare for future climate impacts.

1. Introduction

Scenario planning approaches are increasingly used in climate change research to identify future vulnerabilities and examine adaptation options. This work builds on a long history of futures work in diverse areas including military planning (Kahn, 1964), disaster risk reduction (Tomaszewski et al., 2016), climate change mitigation (IPCC Climate Change, 2014), social development (Butler et al., 2016; Institute for Alternative Futures Vulnerability 2030, 2011Institute for Alternative Futures Vulnerability 2030, 2011), ecology and resource management (Wesche and Armitage, 2014; Bohensky et al., 2006; Palomo et al., 2011), and health planning (World Economic Forum, 2013; Martens and Huynen, 2003). Scenarios are defined broadly as an internally consistent description of a plausible or possible future state of a system (IPCC, 2015; Birkmann et al., 2013).

The majority of scenarios work in the climate change impacts, adaptation, and vulnerability (IAV) field have been top-down in nature, led by the scientific community and typically engaging experts in academia, practitioners, consultants, and government to inform the creation of plausible futures at a regional or national scale (e.g. IPCC's SREX scenarios (IPCC, 2012). Increasingly, however, 'bottom-up' scenarios that work with impacted or vulnerable communities are being developed to aid social learning, and plan for adaptation in-light of multiple stresses, uncertain climatic conditions, and competing policy priorities (Wesche and Armitage, 2014; Addison and Ibrahim, 2013; CARE, 2011; Kok et al., 2006; Oteros-Rozas et al., 2016). Such approaches, commonly referred to as participatory scenario planning (PSP), offer additional benefits to top-down approaches, including increasing the local understanding of how climate change may impact local lives, enabling the identification of contextually appropriate adaptation options, encouraging multi-stakeholder evaluation of adaptation options, and promoting the incorporation of multiple forms of understanding, including both western science and traditional knowledge (Butler et al., 2016; CARE, 2011; Bizikova et al., 2011; Oteros-Rozas et al., 2015).

The Arctic is experiencing dramatic climate change and is the region where the most pronounced future warming is projected (ACIA, 2004). These changes have implications for human livelihoods and are being experienced in the context of other social, economic, political, and environmental changes that influence how people understand and respond to climate change risks (ACIA, 2004). To date, most IAV research in the Arctic has focused on identifying and describing current climate-related exposure-sensitivities and adaptive strategies (Ford et al., 2014). When future vulnerabilities have been considered, they have

* Corresponding author at: The Priestley International Centre for Climate, University of Leeds, UK.
E-mail address: gy08mjf@leeds.ac.uk (M. Flynn).

http://dx.doi.org/10.1016/j.envsci.2017.10.012
Received 21 December 2016; Received in revised form 17 October 2017; Accepted 17 October 2017
Available online 05 November 2017
1462-9011/

often been done so as hypothetical extrapolations of current conditions and responses (Ford et al., 2014; Pearce et al., 2011). Limited work, however, has reviewed how future drivers of change in the Arctic have been captured in IAV research, or examined how/if scenario planning approaches have been used. Against this backdrop, we systematically review the peer-reviewed and grey literature to identify and evaluate how PSP is being used in community-based climate change IAV research across the Arctic.

2. Methods

2.1. Systematic review methodology

We employ a systematic review of the peer-reviewed and grey literature to identify and evaluate how participatory scenario planning (PSP)–which also captures scenario building/development/analysis and is occasionally referred to as participatory visualization/visioning or storytelling–is being used in community-based climate change impacts, adaptation, and vulnerability (IAV) research in the Arctic, following steps outlined by Berrang-Ford et al. (2015) (Supplementary material (SM) Table 2 for definitions of key terms). Peer reviewed documents were identified through key academic databases (Web of Science, Scopus, PubMed, PAIS International and GreenFILE) (SM Table 3 for search terms). To select relevant grey literature, we first performed a search of Google Scholar, where the first 600 returned results were loaded into the reference management software (Zotero, version 4.0), followed by hand searching of key Arctic websites (see Fig. 1) (Haddaway et al., 2015). Inclusion and exclusion criteria were used to identify relevant studies (SM Table 4) and focused on capturing PSP studies that occurred in an Arctic community. Reviewed studies had to utilize scenarios, visioning, or projections to assess future vulnerability, impacts or adaptation strategies to climate change. The studies were also required to include some form of participation from community members or local decision makers. Key methodological limitations for this study include the limited ability to access information that is not publicly available online and the English-centric focus of the articles covered. Thus the paper may underreport the prevalence of studies based in European and Russian Arctic communities or specific regions such as, Nunavik in Northern Quebec. Study selection took place in three stages. Firstly, after conducting the initial web-based searches, duplicate sources were removed and the title of the source was reviewed. If clear exclusion criteria could not be met at this stage the source would move through to stage two, where a review of the paper abstract was used to determine suitability. Finally, a more in-depth review of the source (e.g. journal article or government report) took place to determine if inclusion criteria were met (Fig. 1). The review process was iterative and following this first round of searches we believed that some potentially key documents were still not captured. Consequently, snowball sampling of citations from articles were also added to the referencing management software and reviewed. An additional search of all academic databases and Google Scholar was also performed when the word “visioning” appeared in several relevant articles. This search term had not been included in the original search cycle.

2.2. Analysis

2.2.1. Descriptive analysis

Seventy-three documents were retained for analysis. Of these documents a number referred to the same original study, and so the data of these overlapping studies were combined to create 43 total studies for review. A survey was created to systematically extract qualitative data, and information was extracted based on four key themes: (1) key document information including title and authorship, (2) basic information, including the location of the study and the date it took place, (3) methodology, including information regarding scenario creation, degree of community participation and use of traditional knowledge (TK), and (4) utilization of PSP approaches, which included the consideration of key drivers explored in scenarios (both environmental and socio-economic) and which key sectors were utilizing PSP (see SM for questionnaire). This database was exported into Microsoft Excel and used to calculate descriptive statistics including distribution of studies and frequency of occurrence counts as an overview of key trends and insight into methodologies.

2.2.2. Evaluation rubric

An evaluation rubric was then developed based on a review of the general PSP scholarship to examine the extent to which Arctic PSP studies have incorporated ‘best practices’ and ‘participation’ into research design. A review of nine key documents, from the general PSP literature, identified some best practice for PSP methodologies (See SM Table 6). Six key stages were consistently reported to underpin PSP work in diverse contexts:

1. *Context gathering*. Collecting background information on the current situation provides local context. Participation at this stage facilitates knowledge co-production and is particularly important where there are limited locally identified climate impacts based on broader climate projections.
2. *Identification of key trends and/or drivers*. The identification of key trends and/or drivers determines those changes perceived as most important in the community. Such drivers can be climatic (e.g. changes in precipitation) and/or non-climatic (e.g. loss of traditional land skills).

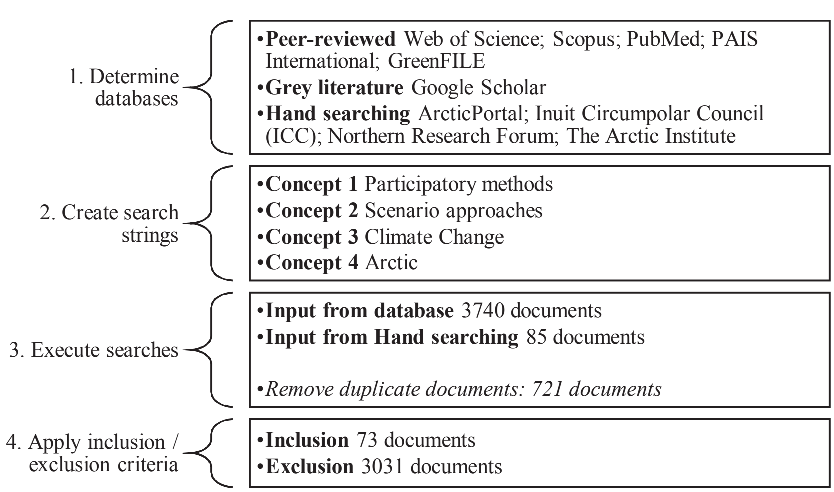

Fig. 1. Overview of systematic review methodology.

3. *Scenario creation*. The creation process is varied, ranging from community members creating their own narratives of possible/desirable futures, to researchers completing this step and presenting it back to the community.
4. *Scenario reviews*. A discussion of the impacts of the scenarios on locally relevant sectors and consideration of the information included in them is widely reported to increase social learning and understanding between stakeholder groups.
5. *Option identification*. Consideration of what options might be available to address the impacts highlighted. Community identified options are often more contextually and culturally appropriate, increasing acceptability of adaptation options and community buy-in.
6. *Option rating*. A system of determining the best options going forward, using option rating can increase the transparency of policy choices and aid decision-making.

The studies retained for full analysis were assessed in two ways: firstly, on their completion of the methodology per the 6 stages of the evaluation rubric, and secondly on the level of participation. Participation was determined by searching through study methodologies to identify stages where clear input was provided by community stakeholders. A simple scoring scheme was developed through which each reviewed study was scored per the rubric, with 1 point allocated for the completion of each of the 6 stages, with total scores thus ranging from 1 to 6 for each study and derived by adding up sub-component scores. Studies were then classified as: "high" where it was evident that studies had completed five or more stages; "medium" where 3–4 stages were evident; and "low" where two or fewer stages were evident. A similar method was applied for determining a participation rating, although studies here were allocated with one point for each stage completed in a participatory way (i.e. with community stakeholder input into the stage). These two ratings are not combined but analyzed separately. While the approach provides a systematic and simple way of evaluating the reviewed studies, we also note that the analysis is only based on publicly available information for each study.

3. Results

3.1. Participatory scenario planning is increasingly common, but climate projections are underutilized

Our review identified 43 studies over the past 15 years utilizing PSP approaches in an Arctic IAV context. There has been increasing interest in PSP work over the last decade, with a peak number of studies identified for 2015. Future climate change projections derived from global circulation models (GCMs) or regional climate models (RCMs) are utilized in just over half of the studies reviewed (58%). This included the use of GIS and mapping software to give specific details of impacts across the study area; for example, Kvalvik et al. (2011) quantitatively projected changes in the length of agricultural growing season for municipalities in northern Norway, using downscaled projections for future climatic variables developed for each municipality. These showed historical and projected changes in temperature, growing seasons, and precipitation conditions for 2021–2050 based on three emission scenarios. Another notable example includes the Scenarios Network for Alaska and Climate Planning (2016) which created a community charts tool to provide temperature and precipitation projections for 4000 communities across the US and Canada up to 2099, including Alaska (n = 444 communities) and Canada's Northwest Territories (n = 47 communities).

In other studies, future projections were based on general trends or expected changes broadly outlined by GCMs, for example, a consideration of high (4 °C of warming) or low climate change futures (2 °C of warming) (Wesche and Armitage, 2014, 2010; Ogden, 2007). Other studies utilized "if-then scenarios" to determine how community members would cope with climate change impacts. Keskitalo and Kulyasova (2009), for example, used statements on future climate change impacts from international, regional, and national assessments in their work with reindeer herders and the fisheries sector, using broad trends to explore with stakeholders how they might be impacted (e.g. by larger variations in weather, warmer water temperatures and northward shifts in fish species).

Studies that did not utilize climate change projections (42%) used alternative methods for determining future drivers and impacts. A common approach involved focusing on specific impacts that had been observed locally to stimulate discussion on future adaptation strategies (Chapin et al., 2016; Collaborative for Advanced Landscape Planning., 2016; Douglas et al., 2014; Hanssen-Bauer, 2015; Harper et al., 2012; Hawley et al., 2016; Hovelsrud et al., 2010; Muir et al., 2014; NorthPortal., 2016; Willox et al., 2013). Some studies used environmental modelling of hydrological, vegetation type or snow-cover to create future scenarios based on current trends ((Na'ia) et al., 2008; Altaweel et al., 2009; Forbes, 2015; Johnson et al., 2015; Jones et al., 2015). Jones et al. (2015) for example, used a baseline of observed climate variability and then increased this variability by a factor of 1, 2, and 3 times to consider the impacts of increased climate variability on driftwood harvest. In other studies, participants created scenarios based on an axis with opposite sentiments at each end, for example, high cumulative impacts to low cumulative impacts (see Text Box 1 in SM) (Beach and Clark, 2016). Finally, some studies used future scenarios based on broad trends in the literature, which were presented to workshop participants. In van Oort (2016), presentations were given regarding expected climate change impacts, with participants deciding what key drivers of change and applying the global shared socio-economic pathways to determine how these local drivers may behave in different future scenarios.

3.2. Participatory scenario planning is engaging with environmental and socio-economic drivers of change in diverse sectors

Consideration of both environmental and social drivers of change is particularly important when examining future vulnerabilities and adaptation options in PSP work, and most studies reviewed included both (95%). Environmental drivers used in studies included changes in temperature and/or precipitation, climate variables most readily included in global circulation models (18%). For example, Carlsen et al. (2013) used standard deviations of temperature in Paris during the 2003 heatwave imposed on a regional projection for climate change in Umea, Sweden, in 2030 to calculate impacts on excess heat-related mortality, hospital admissions, and emergency cases. Other studies used generic climate change projections (20%), where a more general global average temperature increase was usually expressed in terms of more climate change (4 °C warming) or less climate change (2 °C warming) (Hennessey, 2010). Other drivers of future change examined in PSP work were wildlife and vegetation changes (19%), for example, the availability of lichens for reindeer in Northern Europe (Hanssen-Bauer, 2015; Forbes, 2015; Tyler et al., 2007) or the migration of fish populations in Northern Europe and Russia (Keskitalo and Kulyasova, 2009; Keskitalo, 2009); weather patterns (16%), such as the early arrival of spring (Kvalvik et al., 2011; Keskitalo and Kulyasova, 2009; Keskitalo, 2009); oceans and coasts (15%) including a reduction in sea ice and increased storm surge (Johnson et al., 2015) or increase in ocean temperatures (Hovelsrud et al., 2010); permafrost (6%); and changes in freshwater availability (6%) (SM Fig. 6).

Socio-economic drivers of change examined in PSP studies (SM Fig. 7) often focused on economic influences (24%). Wesche and Armitage's (2014, 2010), work in the Slave River Delta region of the Northwest Territories, Canada, for instance, used climate change projections, local knowledge collected through interviews, and historical information on resource extraction, to create scenarios for the year 2030. These scenarios were presented at a community workshop and used as a focal point to identify community vulnerability to impacts, the

implications for local livelihoods, and to identify anticipatory adaptation options. Another driver often used in scenario creation related to changes in traditional activities (23%), for example, in reindeer herding (Forbes, 2015; Barklund, 2007; Käyhkö et al., 2016; Pogodaev and Oskal, 2016; Turunen et al., 2016) or subsistence hunting (Berman and Kofinas, 2004; Berman et al., 2004; Pearce et al., 2012). In Turunen et al's (2016) study in Northern Finland, models of future snow conditions were created based on current snow patterns, weather data and climate projections for 2035–2064. Local reindeer herders were then interviewed about coping strategies.

Drivers of change related to transportation and infrastructure (15%) included future marine shipping routes as Arctic sea ice continues to melt at alarming rates (ACIA, 2004; Brigham, 2015; Stewart et al., 2015; Baker et al., 2012). Brigham's (2015) work on Arctic shipping routes discusses a plausible future set in 2050, key impacts were increased resource extraction, seasonal use of shipping routes, and a wildcard impact of the export and sale of Arctic freshwater to water scarce countries. Finally, another key driver considered in scenario creation was government policy (13%), for example, the consideration of national park management in Alaskan forests (Ernst and van Riemsdijk, 2013), a reflection on alternative scenarios for mining in Sweden (van Oort, 2016) and consideration of fishing quotas in Norway and Russia (Keskitalo and Kulyasova, 2009). Of the studies reviewed, 9% identified other socio-economic indicators and 2% did not identify any socio-economic indicators, choosing instead to focus solely on environmental drivers of change.

When considering how climate change might impact different sectors (Fig. 2), the reviewed studies focused primarily on three major sectors. Firstly, traditional livelihoods (29%), which was often closely linked to health sector impacts (19%) or through increased travel costs or safety concerns for subsistence hunting (Berman and Kofinas, 2004; Berman et al., 2004; Kruse et al., 2004). Secondly, on resource management including the consideration of forestry, fishing, and mining (21%) (Ogden, 2007; Hovelsrud et al., 2010; NorthPortal., 2016; Keskitalo, 2009; Ernst and van Riemsdijk, 2013; Lange and Roderfeld, 2016). Resource extraction is often discussed in the context of climate change due to the expected increase in accessibility of northern resources (ACIA, 2004; Government of Manitoba University of Winnipeg and null, 2010). Finally, impacts and options for community planning (9%) were linked with increasing demand for housing in Canadian Arctic communities, including cases in Clyde River (Collaborative for Advanced Landscape Planning., 2016), Iqaluit (The Municipal Corporation of the City of Iqaluit, 2016) and Whitehorse (Hennessey, 2010). Studies also explored impacts on shipping routes (8%) and the tourism sector (8%).

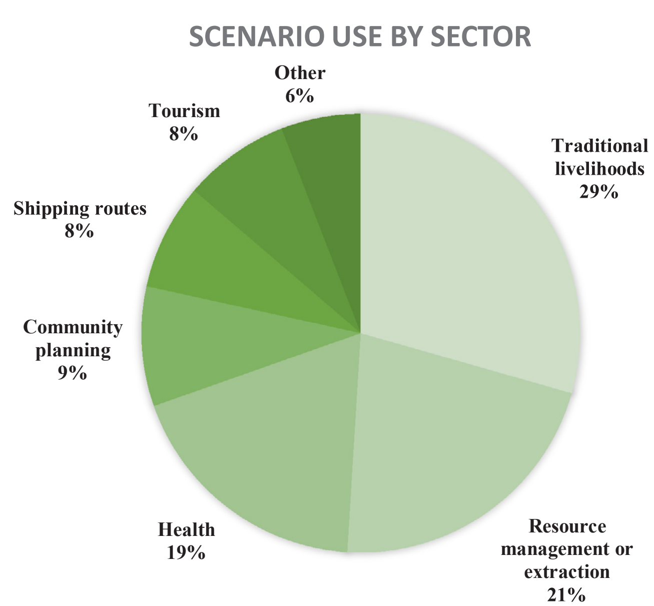

Fig. 2. Sectors engaged in PSP in the Arctic identified through this systematic review.

3.3. Studies followed 'best practice' for participatory scenario planning, but community participation varied among cases

Participatory scenario planning necessitates active involvement and collaboration with community members and local, regional, and national organizations that use this research to inform decision-making. The 43 studies reviewed were evaluated against six components of an evaluation rubric (see Section 2.2.2.) (Fig. 3). Many studies (56%) were found to have completed either five or six of the proposed stages of best practice in PSP and were thus ranked high. Components involving context gathering (79%), creation of scenarios (79%), identification of key drivers (72%), and exploring adaptation options (72%) were most commonly completed, compared to reviewing the scenarios created (65%) and the rating of adaptation options (26%). By sector, studies performing highly were tourism, where 75% of studies were rated as high, community planning (60%), resource management (55%), traditional livelihoods (50%), and health and wellness (43%). Studies looking at the shipping sector did not have any studies utilizing 5 or more stages of the process.

In addition to examining the completion of key PSP components in the reviewed studies, a participation rating, determined through the evaluation rubric, was also provided. Herein, 14% studies were ranked as high participation, 46% received a medium rating, 33% a low rating, and three studies (7%) were not given a score as it was unclear at which stages participation occurred. There has been an increase in participation over time (SM Fig. 9). Sectors with the highest participation ratings were community planning (22%), followed by studies focused on climate change adaptation and traditional livelihoods (17%), and tourism (12%).

The engagement of community members in the different stages was analyzed to examine how community participation in PSP varied over the stages of the process. The stages concerned with 'context gathering' and 'option identification' were the most often completed in a participatory way (67% and 63% respectively), followed by 'scenario review or feedback' (56%). Fewer studies utilized participatory methods in the 'identification of key drivers' (37%) and the 'creation of the scenarios' (33%). Wesche and Armitage, (2014) explain why this was the case in their work, where initial plans included the participatory creation of scenarios but the process was altered to have the researchers create the scenarios due to constraints on time, funding, and local capacities. Ernst and van Riemsdijk's (Ernst and van Riemsdijk, 2013) study scored highly on participation and focused on sustainable forest management in Alaska's national parks in the context of climate change. The process began with two preliminary webinars where background information was provided, with workshops taking place over four days and included participants from National Park Services, local community members, federal agencies, and Alaskan Native representation. Participants were divided into two groups and workshop facilitators encouraged them to discuss future climate possibilities and effects. Following this, groups selected two effects and wrote narratives for two scenarios, which were then discussed and management options created to deal with the future scenarios. Increased participation by multiple stakeholders was found to strengthen climate adaptation options through providing local context and empowering local community members.

3.4. Most studies utilized the forecasting approach; though a back-casting approach resulted in higher local participation

Scenario creation follows two approaches, either considering the future from the vantage point of the present (forecasting) or through creating a desirable future situation and determining the required steps needed at present to reach that future (back-casting) (van Notten et al.,

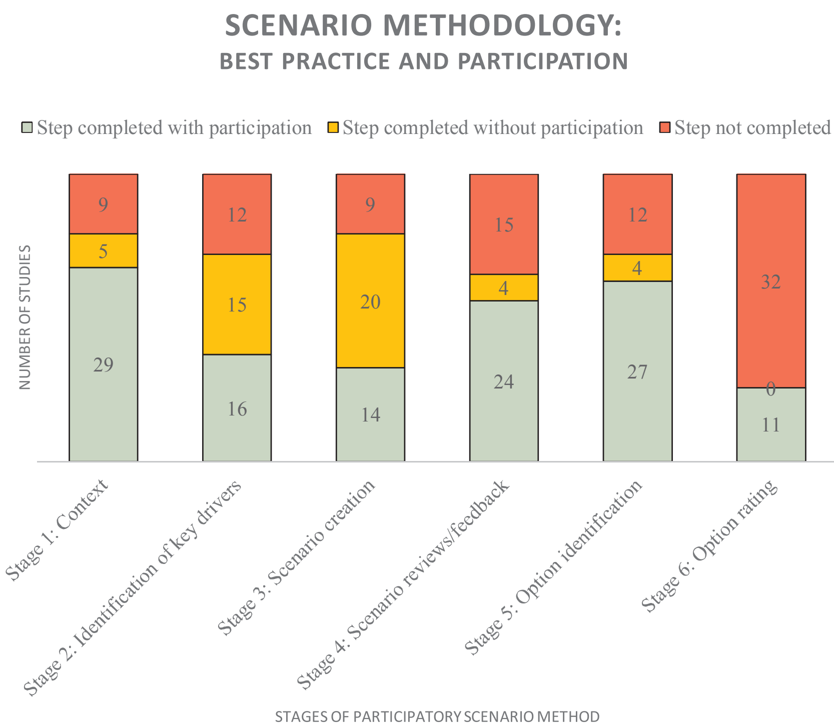

Fig. 3. A chart to show best practice in PSP methodology. Shows key stages in the process, stages completed and utilization of participatory methods for each stage.

2003). The decision on which vantage point to create scenarios from is influenced by the purpose of the scenario workshops. Of the studies reviewed, 84% created scenarios beginning from the vantage point of the present (forecasting), with the remainder utilizing the back-casting approach where a desirable future situation was created and participants identified the required steps to create that future scenario.

The identification of adaptation options was undertaken in most studies reviewed (72%) (Table 1), implying that decision making and planning were key PSP goals. Adaptation options identified in forecasting scenarios were generally narrower in scope than those using back-casting, focusing mainly on adaptation towards a specific projected climate change impact. The majority of the back-casting scenarios took place in the North American Arctic (n = 5) with one study in Finland (Mettiäinen, 2015) and one regional study focusing on Norway, Sweden, and Russia (Pogodaev and Oskal, 2016). Local community members were generally more engaged in these studies than in forecasting: 85% of back-casting studies were ranked as either high or medium participation score (compared to 56% of studies using the forecasting approach). Many of the scenarios utilizing this approach were linked to community planning, including the creation of community development plans in Clyde River, Nunavut, using visualizations of a future community to help consider energy use, future natural hazards, and desirable housing types (Collaborative for Advanced Landscape Planning., 2016). Alternatively, a community sustainability plan created a vision for Iqaluit, Nunavut (The Municipal Corporation of the City of Iqaluit, 2016), and did not outline specific adaptation options per se, instead identifying action points through which the desired end goal could be achieved despite climate change impacts. The vision was created through community meetings and the collection of ideas through a community exhibition.

Utilizing a combined approach to scenario creation is becoming more common in climate change adaptation and allows the production of "local scenarios embedded in global pathways" (Nilsson et al., 2016), meaning that local scenarios are consistent with the global drivers and

Table 1
Example of adaptation options identified in scenarios reviewed in this study.

Authors	Examples of identified adaptation options
Beach, D. M., & Clark, D. A.	– Manage population numbers of wood bison.
	– Regulate movement of bison through the Yukon.
Chapin, F. S., Knapp, C. N., Brinkman, T. J., Bronen, R., & Cochran, P.	– Clarify subsistence rights to access culturally appropriate and affordable food.
	– Document flood history and erosion monitoring
Douglas, V., Chan, H. M., Wesche, S., Dickson, C., Kassi, N., Netro, L., & Williams, M.	– Improve food storage and food conservation through traditional education.
Ernst, K. M., & van Riemsdijk, M.	– Coordinate communication with other agencies.
	– Tune planning process to account for multiple possibilities.
Hawley, M., Booth, P. I., Foster, D., Foster, D., Norton, R., Sage, R., & others.	– Build an evacuation road.
	– Locate the community near marine subsistence resources.
Hennessey, R.	– Establish multi-year infrastructure funding for climate variability.
	– Develop a residential fire strategy.
Johnson, K., Solomon, S., Berry, D., & Graham, P.	– Annually replenish the shore bank with gravel and sand.
	– Control development in shoreline erosion risk area.
Käyhkö, J., Horstkotte, T., Kivinen, S., & Johansen, B.	– Sustainable reindeer herding practices.
Muir, D., Cooper, J. a. G., & Petursdottir, G.	– Conduct a climate vulnerability analysis for all exposed buildings.
Ogden, A. E., & Innes, J. L.	– Minimise fragmentation of habitat and maintain connectivity.
	– Protect climate refugia at multiple scales.
Pearce, T., Ford, J. D., Caron, A., & Kudlak, B. P.	– Extend participation in land camps to older generation community members.
	– Review and update emergency response plans.

boundary conditions influencing local futures (Nilsson et al., 2016; Star et al., 2016). For example, a purely bottom-up approach may see a community addressing permafrost erosion through the construction of a community dock. However, incorporating the Arctic marine shipping assessment scenarios may identify increased future shipping routes close to the community, representing new opportunities for tourism/trade in the community and making a larger port a viable and potentially lucrative adaptation option.

4. Discussion

While participatory scenario planning (PSP) has been widely promoted in the general literature, its utilization remains nascent in the Arctic. With the Arctic projected to experience accelerated climate change this century, PSP is important for informing decision making to manage expected future risks and take advantage of new opportunities. Here, we discuss opportunities and challenges for the application of PSP in IAV work in the Arctic.

First, the importance of involving community members and decision makers in IAV is widely recognized, with PSP work cited as having many potential advantages in creating outcomes that are locally relevant and appropriate for adaptation planning (Wesche and Armitage, 2014; Kok et al., 2006; Carlsen et al., 2013). However, few studies reviewed here were fully participatory in nature, with several challenges to effective participatory methodologies reported, including significant time commitments. Workshop sessions, for instance, in the reviewed studies were recorded to last from four hours (17% of studies) to up to a week (8% of studies), with 42% of studies utilizing a one-day workshop format, and 17% of studies using three-day workshops. An increased number of workshops was linked to higher participation and reported to underpin effective collaboration of communities. These multiple day workshops are a substantial time burden and require a high degree of community buy-in, resources, and logistical organization.

Second, the scenarios created during PSP are highly contextual ‘snapshots’. The inclusion of different stakeholders (even from the same recognized stakeholder group) or the timing of a workshop during a moment of political upheaval, or after a major local event, such as a flood or fire, can influence the outcome of the scenario workshop. Decision making and adaptation planning occur in a world of imperfect knowledge and where a stakeholder’s socio-economic status, experiences, and ideological views will influence their risk perception and decision making. Additionally, the vulnerability of individuals and even entire communities also fluctuates over time (Penn et al., 2016; Fawcett et al., 2017). Despite this lack of reproducibility in scenario creation, the approach still offers a robust process for incorporating stakeholders into decision making, which can improve trust and social learning between researchers and local community members. Treating this process as iterative and flexible can also go some way to minimizing this challenge.

Third, future climate change projections are underutilized in Arctic PSP work, with 42% of the reviewed studies not including them. In some cases, for example, if scenarios are created for the short term (the next 30 years or less) utilizing climate projections may not make sense. However, in the reviewed studies, those cases which did not utilize climate projections were not clearly divided into categories where short-term projections (the next 30 years) did not use projections and long term (the next 51–100 years) scenarios did use projections. We found that 11 studies creating short and medium-term scenarios (those considering up to 50 years in the future) did in fact utilize projections in their work. Thus, we do not believe that a short-term scenario timeline is the limiting factor in the limited use of projections. Instead, we believe this underutilization likely reflects several factors, including: i). Uncertainties surrounding climate projections, which increase dramatically at a local scale, exacerbated by an absence of long-term reliable datasets on local climatic conditions in many Arctic regions and wide variation in factors affecting local climatology (Ford et al., 2016); ii). Limited capacity to utilize projections, reflecting a lack of technical expertise to work with and interpret the output of climate models, or limited capacity at the local level to consider the global drivers which may affect local impacts (Wesche and Armitage, 2014, 2010). Notwithstanding this challenge, user-friendly climate projections are available for some Arctic regions (e.g. Scenarios Network for Alaska and Arctic Planning (SNAP) which are freely available online); iii). Reticence to discuss possible future events by some Arctic Indigenous populations (see below) (Bates, 2007; Natcher et al., 2007; Krupnik and Jolly, 2015); and iv). Climate projections are still limited in producing future projections on key Arctic environmental factors including, future extreme weather and storms and wind strengths and directions (Hovelsrud et al., 2010). It is also noteworthy that alternative approaches to the use of climate projections have been used in Arctic PSP work, including extrapolating current trends and using observations of present-day vulnerabilities as indicative of future risks and drivers. While offering important insights, focusing on the present-day risks potential maladaptation given the magnitude of climate change projected for the Arctic (e.g. investment in coastal defenses to combat current erosion which may be overwhelmed by future sea level rise).

Fourth, difficulty in integrating traditional and local knowledge was listed as a barrier in 18% of cases and necessitates careful consideration and reflection. Arctic governance involves a broad range of stakeholders, at the local level this includes Arctic Indigenous peoples, who can be considered rightsholders rather than merely stakeholders. Their participation in the decision making processes is required and they hold these rights based on national treaties, such as The Nunavut Land Claims Agreement (NTI, INAC and OFI-MSNI, 2010) and international agreements, such as the United Nations Declaration on the Rights of Indigenous People (United Nations, 2017). In addition to Indigenous Arctic peoples, other key stakeholders include, non-Indigenous Arctic residents, municipal or community governments, federal organizations (e.g. National Park staff), international organizations such as the Arctic Council and private businesses with Arctic interests including fisheries and shipping companies. These diverse stakeholders have contrasting priorities for the region and participatory scenario planning outcomes are likely to vary significantly based on the make-up of the participant workshop. Ernst and van Riemsdijk (2013), for example, discuss the implications of having a limited mix of Arctic stakeholders in workshops, noting that when the majority of the group belonged to one particular stakeholder group, this led to a less varied discussion of options, and a tendency to defer to those stakeholders who were perceived as authorities (in this case, National Park officials). Other studies discussed strategies to manage the power differentials that can exist within these stakeholder groups. The Sustainable Iqaluit City Plan, addressed the potential for power imbalances in local group dynamics by hosting separate stakeholder group meetings. Balancing local level input with broader goals of PSP was also reported to be challenging in a climate change context, with local stakeholders more likely to identify local drivers which directly impacted their day to day lives, and to the neglect external and longer term drivers of change, which were more abstract and less clearly linked to local impacts (Wesche and Armitage, 2014). Van Oort (2016) countered this by integrating global context into the scenario process but participant feedback described this process as challenging and some felt it took away from the discussion of pertinent local issues.

Finally, while many PSP studies focused on integrating western science and traditional knowledge (TK), cultural factors may impact the utility and appropriateness of the approach in Indigenous communities. Integration of knowledge is acknowledged as a key strength of PSP (Bizikova et al., 2011; Pahl-Wostl, 2015; Rounsevell and Metzger, 2010). The majority of studies reviewed (67%) had some evidence of the inclusion of TK through stakeholder discussions with Elders and other community members who were asked to provide context and background for baseline information prior to scenario creation (e.g. in identifying availability and use of freshwater sources, discussing

subsistence hunting patterns to provide model validation through focus groups), were consulted on how development should occur in their town or hamlet, and/or were asked to review and add insight to researcher created scenarios. In many cases, however, it was difficult to determine what components of TK were included in the study (see Usher 2000) and to what extent. This is problematic as studies often claim to engage TK, but participation is not necessarily synonymous with knowledge sharing. Thought needs to be given to the design of PSP to avoid creating a structure and approach that is incongruent with the sharing of TK. For example, sector-specific workshops held in abstract environments (e.g. meeting rooms) may not be suitable to capture the holistic nature of TK that is generated and shared through stories and interactions with the natural environment. Researchers may need to reconsider their approach and methods for PSP if they wish to include TK, including providing communities with the necessary information and resources to facilitate PSP processes themselves.

Although the inclusion of TK is encouraged in PSP work and IAV research more generally, there are also tensions associated with this in an Arctic context. A number of Arctic Indigenous populations perceive and record time as a cyclical process, usually reflecting the passing of the seasons in one year periods with limited consideration given to long-term futures, contrasting to Western understandings of time as linear (Natcher et al., 2007). This has implications for futures research and can create situations where researchers are imposing Western worldviews and perspectives on communities. In the context of Inuit communities, Bates (2007) identifies contrasting philosophies in Inuit and Western understandings of planning for the future. Inuit philosophies are often based on knowledge and understanding of current conditions and an acceptance that the future will be uncertain, where an overreliance on planning can be seen as reducing the ability to prepare and react flexibly to situations. There are also taboos that can impact the discussion of future environmental conditions and the creation of scenarios. For some Inuit philosophies, for instance, it can be seen as arrogant to assume you can predict the behavior of animals and the environment (Bates, 2007). Additionally, some Indigenous cultures have belief systems which interpret some natural phenomena as sentient (Natcher et al., 2007; Ford et al., 2008), where thoughts and words are believed to be able to influence the future, and therefore, people are reluctant to 'tempt fate' by talking about negative future possibilities.

Whilst these contrasting ways of knowing present significant difficulties in navigating PSP in Indigenous communities, this review has identified several successful strategies to ensure meaningful and respectful participation in futures research. Successful approaches include the utilization of Inuit artists in the visualization of scenarios (Wesche and Armitage, 2014, 2010), the utilization of positive visioning exercises where communities are asked to express hopes and wishes for the future (Collaborative for Advanced Landscape Planning., 2016; The Municipal Corporation of the City of Iqaluit, 2016). Additionally, community-based research can help in addressing potential tensions in Worldviews through ensuring that Indigenous researchers and community members are involved from the planning stages of the process (Harper et al., 2012; Willox et al., 2013).

5. Conclusion

In this paper, we systematically identify and evaluate how participatory scenario planning (PSP) is being used in community-based climate change impacts, adaptation, and vulnerability (IAV) research in the Arctic. We find that PSP work is increasingly being used as studies begin to examine future drivers of change in-light of significant climate impacts. The studies that have been conducted generally perform well in terms of following recognized steps for conducting PSP, although many do not incorporate projections of future climate impacts. Participation levels across studies varied by PSP stage, with the lowest participation noted in the identification of key drivers of change and the scenario creation stage. There are opportunities for expanding PSP work in the Arctic, and studies reviewed here illustrate examples of methodologies with wide-ranging application. However, ensuring the local acceptability of PSP work is critical and research with Indigenous community members should carefully consider the cultural context and local worldviews.

Acknowledgments

Funding for this work was provided by CIHR, NSERC, SSHRC,IDRC, ArcticNet, and a CIHR Applied Public Health Chair.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.envsci.2017.10.012.

References

(Na'ia), Alessa L, (Anaru), Klinskey A, Busey, R., Hinzman, L., 2008. White D, others. Freshwater vulnerabilities and resilience on the Seward Peninsula: integrating multiple dimensions of landscape change. Glob. Environ. Change 18 (2), 256–270.

ACIA, 2004. Impacts of a Warming Arctic Climate Impact Assessment [Internet]. Cambridge University Press, UK (Available from: http://library.arcticportal.org/1299/).

Addison, A., Ibrahim, M., 2013. Participatory Scenario Planning for Community Resilience London. World Vision, UK September.

Altaweel, M.R., Alessa, L.N., Kliskey, A.D., 2009. Forecasting resilience in arctic societies: creating tools for assessing social–hydrological systems. J. Am. Water Resour. Assoc. 45 (December (6)), 1379–1389.

Baker, I., Peterson, A., Brown, G., McAlpine, C., 2012. Local government response to the impacts of climate change: an evaluation of local climate adaptation plans. Landsc. Urban Plan. 107 (August (2)), 127–136.

Barklund, A., 2007. Future Challenges for Reindeer Herder Societies. In: Future Challenges for Reindeer Herding Societies [Internet]. Umeå, Sweden (Available from: http://library.arcticportal.org/425/).

Bates, P., 2007. Inuit and scientific philosophies about planning, prediction, and uncertainty. Arct Anthropol. 44 (January (2)), 87–100.

Beach, D.M., Clark, D.A., 2016. Scenario planning during rapid ecological change: lessons and perspectives from workshops with southwest Yukon wildlife managers. Ecol. Soc. [Internet] 20 (1). [cited 2016 Jan 12] (Available from: http://www.ecologyandsociety.org/vol20/iss1/art61/ES-2015-7379.pdf).

Berman, M., Kofinas, G., 2004. Hunting for models: grounded and rational choice approaches to analyzing climate effects on subsistence hunting in an Arctic community. Ecol. Econ. 49 (1), 31–46.

Berman, M., Nicolson, C., Kofinas, G., Tetlichi, J., Martin, S., 2004. Adaptation and sustainability in a small Arctic community: results of an agent-based simulation model. Arctic 57 (December (4)), 401–414.

Berrang-Ford, L., Pearce, T., Ford, J.D., 2015. Systematic review approaches for climate change adaptation research. Reg. Environ. Change 15 (5), 755–769 (Feb 22).

Birkmann, J., Cutter, S.L., Rothman, D.S., Welle, T., Garschagen, M., van, Ruijven B., et al., 2013. Scenarios for vulnerability: opportunities and constraints in the context of climate change and disaster risk. Clim. Change 133 (1), 53–68 (Nov 9).

Bizikova, L., Burch, S., Robinson, J., Shaw, A., Sheppard, S., 2011. Utilizing participatory scenario-Based approaches to design proactive responses to climate change in the face of uncertainties. In: Gramelsberger, G., Feichter, J. (Eds.), Climate Change and Policy [Internet]. Springer, Berlin Heidelberg, pp. 171–190. [cited 2015 Dec 14] (Available from: http://link.springer.com/chapter/10.1007/978-3-642-17700-2_8).

Bohensky, E.L., Reyers, B., Van Jaarsveld, A.S., 2006. Future ecosystem services in a Southern African river basin: a scenario planning approach to uncertainty. Conserv. Biol. J. Soc. Conserv. Biol. 20 (August (6)), 1051–1061.

Brigham, L., 2015. Future perspective: the maritime arctic in 2050. Fletcher F. World Aff. 39, 109.

Butler, J.R.A., Bohensky, E.L., Suadnya, W., Yanuartati, Y., Handayani, T., Habibi, P., et al., 2016. Scenario planning to leap-frog the sustainable development goals: An adaptation pathways approach. Clim Risk Manag. [Internet] [cited 2016 Jun 8] (Available from: http://www.sciencedirect.com/science/article/pii/S2212096315000376).

CARE, 2011. Decision-making for Climate Resilient Livelihoods and Risk Reduction: A Participatory Scenario Planning Approach Nairobi. CARE, Kenya Adaptation Learning Programme for Africa.

Carlsen, H., Dreborg, K.H., Wikman-Svahn, P., 2013 Dec. Tailor-made scenario planning for local adaptation to climate change. Mitig. Adapt. Strateg. Glob. Change. 18 (December (8)), 1239–1255.

Chapin, F.S., Knapp, C.N., Brinkman, T.J., Bronen, R., Cochran, P., 2016. Community-empowered adaptation for self-reliance. Curr. Opin. Environ. Sustain. 19, 67–75.

Collaborative for Advanced Landscape Planning, 2016. 4D Visioning for Climate Decision-Making: Strengthening the Local Climate Change Visioning Process for Communities. [Internet]. Collaborative for Advanced Landscape Planning. [cited Jan 4]. (Available from: http://calp.forestry.ubc.ca/4d-visioning-for-climate-decision-

Douglas, V., Chan, H.M., Wesche, S., Dickson, C., Kassi, N., Netro, L., et al., 2014. Reconciling traditional knowledge, food security, and climate change: experience from old crow, YT, Canada. Prog. Commun. Health Partnersh. Res. Educ. Action 8 (1), 21–27 SPR.

Ernst, K.M., van Riemsdijk, M., 2013. Climate change scenario planning in Alaska's National Parks: stakeholder involvement in the decision-making process. Appl. Geogr. 45 (December), 22–28.

Fawcett, D., Pearce, T., Ford, J.D., Archer, L., 2017. Operationalizing longitudinal approaches to climate change vulnerability assessment. Glob Environ Change 45 (Suppl. C), 79–88 (July 1).

Forbes, B.C., 2015. Reindeer Management in Northernmost Europe Linking Practical and Scientific Knowledge in Social-ecological Systems [Internet]. Berlin; [London]: Springer; 2006 [cited Jul 11]. (Available from: http://public.eblib.com/choice/publicfullrecord.aspx?p=304338).

Ford, J.D., Smit, B., Wandel, J., Allurut, M., Shappa, K., Ittusarjuat, H., et al., 2008. Climate change in the Arctic: current and future vulnerability in two Inuit communities in Canada. Geogr. J. 174 (1), 45–62.

Ford, J.D., McDowell, G., Jones, J., 2014. The state of climate change adaptation in the Arctic. Environ. Res. Lett. 9 (October (10)), 104005.

Ford, J.D., Falk, K., Tesar, C., 2016. Adaptation and Resilience. Arctic Council, Adaptation Actions for a Changing Arctic Assessment. Arctic Council.

Government of Manitoba University of Winnipeg, 2010. The Northern Directions–Arctic Gateway Summit. In: The Northern Directions–Arctic Gateway Summit [Internet]. WINNIPEG, CA, Manitoba, pp. 1–50(Available from: http://library.arcticportal.org/1563/).

Haddaway, N.R., Collins, A.M., Coughlin, D., Kirk, S., 2015. The role of google scholar in evidence reviews and its applicability to grey literature searching. PLoS One 10 (9) (September 17 e0138237).

Hanssen-Bauer, I., 2015. Climate Conditions & Scenarios for Herding (WP 1) [Internet]. EALAT. [cited Mar 26]. (Available from: http://icr.arcticportal.org/work-packages/249-work-package-1).

Harper, S.L., Edge, V.L., Willox, A.C., 2012. Changing climate, changing health, changing stories profile: using an EcoHealth approach to explore impacts of climate change on inuit health. Ecohealth 9 (March (1)), 89–101.

Hawley, M., Booth, P.I., Foster, D., Foster, D., Norton, R., Sage, R., et al., 2016. Although Kivalina Residents Continue to Debate the Location of a Future Village Site, They Speak with One Voice when It Comes to the Need and Desire for Improving Community Health. [Internet]. 2015 [cited Apr 6]. (Available from: https://www.commerce.alaska.gov/web/Portals/4/pub/093015_DRAFT_SMP_Background_Report_Kivalina.pdf).

Hennessey, R., 2010. Scenario planning as a tool to ensure robust adaptation. Plan Can. 50 (4), 32–35.

Hovelsrud, G.K., Dannevig, H., West, J., Amundsen, H., 2010. Adaptation in Fisheries and Municipalities: Three Communities in Northern Norway. Community Adaptation and Vulnerability in Arctic Regions [Internet]. pp. 23–62 (Available from: http://www.scopus.com/inward/record.url?eid=2-s2.0-84863917136&partnerID=40&md5=27425c6282d63a94e10a5165743266ff).

IPCC Climate Change, 2014. Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Internet]. Geneva, Switzerland: IPCC 2015. (Available from: https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf).

IPCC, 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Internet]. Cambridge University Press, Cambridge, UK(Available from: http://www.ipcc-wg2.gov/SREX/images/uploads/SREX-SPMbrochure_FINAL.pdf).

IPCC, 2015. Definition of Terms [Internet]. Intergovernmental Panel on Climate Change: Data Distribution Centre. 2013 [cited Jul 12]. (Available from: http://www.ipcc-data.org/guidelines/pages/definitions.html).

Institute for Alternative Futures Vulnerability 2030, 2011. Scenarios on Vulnerability in the United States. Institute for Alternative Futures, Alexandria USA, pp. 1–48.

Johnson, K., Solomon, S., Berry, D., Graham, P., 2015. Erosion Progression and Adaptation Strategy in a Northern Coastal Community. In: 8th International Conference on Permafrost [Internet]. 2003 [cited Feb 2]. pp. 21–25 (Available from: http://research.iarc.uaf.edu/NICOP/DVD/ICOP%202003%20Permafrost/Pdf/Chapter_087. pdf).

Jones, C.E., Kielland, K., Hinzman, L.D., Schneider, W.S., 2015. Integrating local knowledge and science: economic consequences of driftwood harvest in a changing climate. Ecol. Soc. [Internet] 20 (1).

Käyhkö, J., Horstkotte, T., Kivinen, S., Johansen, B., 2016. Social-ecological Feedbacks Between Climate, Reindeer and People-contributions to Climate Change Adaptation? In: EGU General Assembly Conference Abstracts [Internet]. 2015 [cited Apr 6]. pp. 12836(Available from: http://www.neespi.org/web-content/meetings/EGU2015/Kayhko.pdf).

Kahn, H., 1964. Thinking About the Unthinkable. Avon Books, New York, USA.

Keskitalo, E.C.H., Kulyasova, A.A., 2009. The role of governance in community adaptation to climate change. Polar Res. 28 (1), 60–70.

Keskitalo, E.C.H., 2009. Governance in vulnerability assessment: the role of globalising decision-making networks in determining local vulnerability and adaptive capacity. Mitig. Adapt. Strateg. Glob. Change 14 (Feburary (2)), 185–201.

Kok, K., Patel, M., Rothman, D.S., Quaranta, G., 2006. Multi-scale narratives from an IA perspective: part II: participatory local scenario development. Futures 38 (April (3)), 285–311.

Krupnik, I., Jolly, D., 2015. The Earth Is Faster Now: Indigenous Observations of Arctic Environmental Change. Frontiers in Polar Social Science. [Internet]. ERIC; 2002 [cited Feb 2]. (Available from: http://eric.ed.gov/?id=ED475289).

Kruse, J.A., White, R.G., Epstein, H.E., Archie, B., Berman, M., Braund, S.R., et al., 2004. Modeling sustainability of Arctic communities: an interdisciplinary collaboration of researchers and local knowledge holders. Ecosystems 7 (8), 815–828.

Kvalvik, I., Dalmannsdottir, S., Dannevig, H., Hovelsrud, G., Ronning, L., Uleberg, E., 2011. Climate change vulnerability and adaptive capacity in the agricultural sector in Northern Norway. Acta Agric. Scand. Sect. B-Soil Plant Sci. 61, 27–37.

Lange, M.A., Roderfeld, H., 2016. Balance Project Web Site [Internet]. [cited Jan 21]. (Available from: http://balance1.uni-muenster.de/).

Martens, P., Huynen, M., 2003. A future without health? health dimension in global scenario studies. Bull. World Health Organ. 81 (12), 896–901.

Mettiäinen, I., 2015. Planned or Emerging Futures? Addressing Climate Change on Regional Level by Strategic Planning [Internet]. University of Lapland, Finland: Arctic Centre; 2013 [cited Feb 17]. (Available from: http://www.rha.is/static/files/NRF/OpenAssemblies/AKUREYRI2013/ilonamettiainen.pdf).

Muir, D., Cooper, J.A.G., Petursdottir, G., 2014. Challenges and opportunities in climate change adaptation for communities in Europe's northern periphery. Ocean Coast Manag. 94, 1–8.

Nunavut Tunngavik Inc. (NTI) and the Minister of Indian Affairs and Northern Development (INAC) and Federal Interlocutor for Métis and Non-Status Indians (OFI-MNSI), Nunavut Land Claims Agreement, 2010. (Available from: http://nni.gov.nu.ca/sites/nni.gov.nu.ca/files/06NLCA-Eng.pdf).

Natcher, D.C., Huntington, O., Huntington, H., Chapin, F.S., Trainor, S.F., DeWilde, L., 2007. Notions of time and sentience: methodological considerations for Arctic climate change research. Arct. Anthropol. 44 (2), 113–126.

Nilsson, A.E., Carlsen, H., van der Watt, L.-M., 2016. Uncertain Futures: The Changing Global Context of the European Arctic. 2015 [cited Apr 6]. (Available from: http://www.sei-international.org/mediamanager/documents/Publications/NEW/sei-wp-2015-uncertain-futures-nilssonv2.pdf).

NorthPortal, 2016. NorthPortal [Internet]. 2011 [cited Jan 21]. (Available from: http://www.northportal.info/en/component/content/category/57-background).

Ogden, A.E., 2007. Forest management in a changing climate: building the environmend information base for southwest Yukon. For. Chron. 83 (December (6)), 806–809.

Oteros-Rozas, E., Martín-López, B., Daw, T.M., Bohensky, E.L., Butler, J.R.A., Hill, R., et al., 2015. Participatory scenario planning in place-based social-ecological research: insights and experiences from 23 case studies. Ecol. Soc. 20 (December (4)), 363–428.

Oteros-Rozas, E., Martín-López, B., Daw, T.M., Bohensky, E.L., Butler, J.R.A., Hill, R., et al., 2016. Participatory Scenario Planning in Place-based Social-ecological Research: Insights and Experiences from 23 Case Studies. Ecol. Soc. [Internet] 20 (4). [cited Mar 31] (Available from: http://www.ecologyandsociety.org/vol20/iss4/art32/).

Pahl-Wostl, C., 2015. Chapter Five Participation in Building Environmental Scenarios. In: Developments in Integrated Environmental Assessment [Internet]. Elsevier; 2008 [cited Dec 14]. pp. 105–122(Available from: http://linkinghub.elsevier.com/retrieve/pii/S1574101x08004055).

Palomo, I., Martín-López, B., López-Santiago, C., Montes, C., 2011. Participatory scenario planning for protected areas management under the ecosystem services framework: the Doñana social-ecological system in southwestern Spain. Ecol. Soc. 16 (1), 23.

Pearce, T., Ford, J.D., Duerden, F., Smit, B., Andrachuk, M., Berrang-Ford, L., et al., 2011. Advancing adaptation planning for climate change in the Inuvialuit Settlement Region (ISR): a review and critique. Reg Environ Change. 11 (March (1)), 1–17.

Pearce, T., Ford, J.D., Caron, A., Kudlak, B.P., 2012. Climate change adaptation planning in remote, resource-dependent communities: an Arctic example. Reg Environ Change. 12 (December (4)), 825–837.

Penn, H.J.F., Gerlach, S.C., Loring, P.A., 2016. Seasons of stress: understanding the dynamic nature of people's ability to respond to change and surprise. Weather Clim Soc. 8 (4), 435–446 (Jun 23).

Pogodaev, M., Oskal, A., 2016. Youth. The Future Of Reindeer Herding Peoples. 2015 [cited Apr 6]. (Available from: http://library.arcticportal.org/1804/).

Rounsevell, M.D., Metzger, M.J., 2010. Developing qualitative scenario storylines for environmental change assessment. Wiley Interdiscip. Rev. Clim. Change 1 (4), 606–619.

Scenarios Network for Alaska + Arctic Planning. Scenarios Network for Alaska + Arctic Planning [Internet]. [cited 2016 Jul 4], 2016, (Available from: https://www.snap.uaf.edu/).

Star, J., Rowland, E.L., Black, M.E., Enquist, C.A.F., Garfin, G., Hoffman, C.H., et al., 2016. Supporting adaptation decisions through scenario planning: enabling the effective use of multiple methods. Clim. Risk Manag. 1 (January (13)), 88–94.

Stewart, E., Dawson, J., Johnston, M., 2015. Risks and opportunities associated with change in the cruise tourism sector: community perspectives from Arctic Canada. Polar J. 5 (2), 403–427.

The Municipal Corporation of the City of Iqaluit, 2016. The Municipal Corporation of the City of Iqaluit Sustainable Community Plan [Internet]. Iqaluit, Canada: The Municipal Corporation of the City of Iqaluit; 2014 [cited Jan 27]. (Available from: http://sustainableiqaluit.com/resources/iqaluit-sustainable-community-plan/).

Tomaszewski, B., Schwartz, D., Szarzynski, J., 2016. Crisis Response Serious Spatial Thinking Games: Spatial Think Aloud Study Results. In: Geospatial Data & Geographical Information Science [Internet]. Rio de Janeiro, Brazil(Available from: http://idl.iscram.org/files/andreahtapia/2016/1436_AndreaH.Tapia_etal2016.pdf).

Turunen, M.T., Rasmus, S., Bavay, M., Ruosteenoja, K., Heiskanen, J., 2016. Coping with Difficult Weather and Snow Conditions: Reindeer Herders' Views on Climate Change Impacts and Coping Strategies. Clim Risk Manag [Internet]. [cited 2016 Apr 7]. (Available from: http://www.sciencedirect.com/science/article/pii/S2212096316000036).

Tyler, N.J.C., Turi, J.M., Sundset, M.A., Bull, K.S., Sara, M.N., Reinert, E., et al., 2007. Saami reindeer pastoralism under climate change: applying a generalized framework for vulnerability studies to a sub-arctic social-ecological system. Glob. Environ.

Change-Hum. Policy Dimens. 17 (May (2)), 191–206.
United Nations, 2017. United Nations Declaration on the Rights of Indigenous Peoples [Internet]. United Nations; 2007 [cited Sep 13]. (Available from: http://www.un.org/esa/socdev/unpfii/documents/DRIPS_en.pdf).
Wesche, S.D., Armitage, D.R., 2010. As Long as the Sun Shines, the Rivers Flow and Grass Grows: Vulnerability, Adaptation and Environmental Change in Deninu Kue Traditional Territory, Northwest Territories. Community Adaptation and Vulnerability in Arctic Regions [Internet]. pp. 163–189(Available from: http://www.scopus.com/inward/record.url?eid=2-s2.0-84867686020&partnerID=40&md5=22858097e1369f735035fe8b04a7895b).
Wesche, S.D., Armitage, D.R., 2014. Using qualitative scenarios to understand regional environmental change in the Canadian North. Reg. Environ. Change 14 (June (3)), 1095–1108.
Willox, A.C., Harper, S.L., Edge, V.L., 2013. Storytelling in a digital age: digital storytelling as an emerging narrative method for preserving and promoting indigenous oral wisdom. Qual. Res. 13 (April (2)), 127–147.
World Economic Forum, 2013. Sustainable Health Systems: Visions, Strategies, Critical Uncertainties and Scenarios. World Economic Forum, Geneva, Switzerland.
van Notten, P.W.F., Rotmans, J., van Asselt, M.B.A., Rothman, D.S., 2003. An updated scenario typology. Futures 35 (June (5)), 423–443.
van Oort, B., 2016. Barents Region Futures Under Different Global Socio-economic Scenarios Adaptation Futures. (Rotterdam, The Netherlands May 10).